ON THE PATHOLOGY OF TRANSVERSE FRACTURES OF THE PATELLA AND THE OLECRANON.

SHOWING THE CHIEF CAUSE OF NON-OSSEOUS UNION IN THESE FRACTURES AND HOW TO OBVIATE IT.

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MUCH attention has been paid of late to the treatment of transverse fractures of the patella, and advance has in some quarters been made in this direction. This change in treatment has, however, neither been preceded by researches on the pathology of transverse patellar fractures, nor has it been founded on results such as could have been obtained from such an investigation. Great diversity of opinion consequently exists as to treatment, and the majority of surgeons, entertaining the current views as to the causes of non-osseous union, have adhered to the older methods of treatment. Not being satisfied with the views generally entertained by way of explanation of the causes of non-osseous union of transverse patellar fractures, the writer has since 1879 made observations on the subject. The outcome of these was given in a clinical lecture to the students of the Royal Infirmary School in the spring of 1883 and was subsequently published in the *Lancet* (17th November, 1883). The observations which have been made since that time have fully borne out the conclusions then formulated.

Anatomical Aspects of the Præ-Patellar Aponeurosis.—The tendon of the quadriceps is for the most part inserted into the groove on the upper portion of the patella, the strong aponeurosis being attached to its sides, while the ligamentum patellæ

arises chiefly from its lower border. Over the centre of the anterior surface of the patella it is generally supposed that the aponeurotic fibres are either wanting or are so sparsely distributed as to be scarcely worthy of consideration. This the writer considers to be a mistake, especially when applied to the period of adolescence and full vigorous adult life, as under these circumstances there is a distinct firm band of ligamentous structure, passing over the front of the patella, continuous with the tendon above and the ligament below.

In order to expose the aponeurotic structures in front of the patella so as to enable one to form an estimate of their arrangement and dimensions, the following method was adopted: A longitudinal section was made through the centre of the quadriceps extensor tendon, the patella and the ligamentum patellæ. One-half of the structures so divided was taken, and the portion of the patella which it contained was

FIG. 1. LONGITUDINAL SECTION THROUGH CENTRE OF ARTIFICIALLY FRACTURED PATELLA (representing the upper portion of an artificially produced transverse fracture of the patella, the lower fragment of the patella having been torn from its præ-patellar attachments in order to show the latter. Drawn from an actual specimen taken from a subject (male) 15 years of age).

sectioned transversely at its centre, beginning at its articular surface and passing almost completely through, leaving only a portion anteriorly slim enough to permit of fracture. After breaking this portion the lower half of the sectioned patella was torn from its ligamentous and aponeurotic connections, leaving them exposed. (See Fig. I).

Ten patellæ removed from as many different subjects were thus submitted to examination. They were all obtained in a fresh state and not subsequent to an ordinary dissecting-room course, as after that the parts are generally dried and shrunken. Several of them were obtained from young subjects, one an

infant, one a child of two years, one fourteen, one seventeen and one twenty years. There were four adult males of thirty to forty-five years of age, and two were from subjects above sixty years.

In young children the ligamentous structures running in front of the patella were represented by a very thin film, in many places scarcely distinguishable from the cartilage. In advanced life the præ-patellar tendinous structures were attenuated especially over the centre of the patella. In the six instances ranging from fourteen to forty-five years of age, the aponeurotic structures ran in a distinct band over the front of the patella, continuously from the tendon of the quadriceps to the ligamentum patellæ. The antero-posterior diameter of this layer ranged from one to three millimetres (one-thirty-second to a sixteenth of an inch). The bulk of these fibres were longitudinal, many of them seemingly continuous from the tendon to the ligament. A few were oblique. The examination of these structures during life in cases of transverse fractures of the patella recently produced, coincided with these anatomical observations. In considering these facts in relation to transverse fractures of the patella, it should be remembered that the period in which this fracture is most prone to occur coincides with that in which aponeurotic structures are most developed in front of the patella.

There have been three causes assigned for the want of osseous union after transverse fractures of the patella. First, a supposed deficiency in the patellar blood supply, causing a low vitality of the part and thereby preventing an outpouring of sufficient ossific deposit to unite the fragments together. Second, the separation of the fragments, by the powerful retraction of the quadriceps extensor muscle carrying the proximal portion of the patella upwards away from the lower; and third, the distention of the knee-joint by blood and serum, thus preventing the approximation of the fragments.

Regarding the first of these the facts are entirely against the assumption that there is a deficient supply of blood to the patella. Injected specimens of the vessels going to and from that bone show that the blood supply from its numerous ves-

sels is abundant, and the parenchymatous hæmorrhage which ensues from the cancellated tissue in transverse patellar fractures is a proof not only of its large supply but also of its thorough distribution. The fact that osseous union is so constantly obtained in longitudinal fractures of the patella, and that ossific deposition is so abundant in certain diseased states of that bone, are of themselves evidences that the assertion is untenable.

It has been said that pressure of a bandage during treatment of transverse patellar fractures might arrest the flow of blood into the proximal fragment and osseous union would thereby be prevented. Were this correct, it would equally prevent the formation of connective tissue between the fragments; but there is no lack of a firm and substantial growth of connective tissue there. It would equally apply to the treatment of longitudinal fractures, whereas in the latter osseous union is the rule.

The contraction of the quadriceps extensor muscle, which separates the fragments by pulling up the proximal one, might act as a cause of non-union, provided no attempts were made to bring the fractured portions together. The contractions which at first ensue soon subside, and the muscle remains in a state of rest. The resistance then offered by it is so slight that it is easily overcome, and could not be a cause of non-union, provided ordinary care were adopted. In cases of transverse fractures of the patella coming under the writer's notice in which the parts were exposed shortly after the accident, the upper fragment could with very slight downward pressure, such as that exerted by the fingers, be brought into contact with the lower one.

The effusion of blood and serum into the knee-joint, causing separation of the fragments by distention of the joint, frequently does obtain, but it is seldom sufficient of itself to prevent osseous union because of the rapidity of its resorption. A small quantity of blood clot, on the floor and roof of the fractured edges might even be of service in preventing the wandering into the joint of osteoblasts and in forming a medium in which they might congregate and unite together into osseous plates. The presence of coagulated blood between the

fractured surfaces of bones is constant throughout the body, and is not productive of non-osseous union. Therefore of the three causes formerly assigned for non-osseous union of transverse fracture of the patella, the first is absolutely fallacious, the second is practically inoperative, when the patient is subjected to any of the ordinary methods of placing the fragments in contact; and the third, while it occasionally obtains, does not do so in the majority of cases to an extent sufficient to prevent osseous union. The fact remains, that osseous union of a transverse fracture of the patella treated by the ordinary methods, is rarely attained. It is then evident that in such cases there must be another cause to account for the want of bony union, and that must be one which does not apply to longitudinal fractures of the patella.

In seeking for such an explanation, let the reader's attention

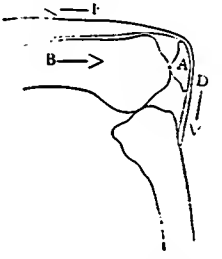

FIG. 2. MECHANISM OF TRANSVERSE PATELLAR FRACTURE. (Diagrammatic).

be directed to the manner in which transverse fractures of the patella are occasioned. It is understood that the majority of transverse patellar fractures are due to violent muscular action, most frequently caused by sudden efforts to maintain the equilibrium, while one is in the act of falling, the knee being slightly bent. The sudden development of the full retractile force of the powerful quadriceps causes the patella to be jerked upwards, relatively to the femur, beyond the position where it usually lies supported laterally by the femoral patellar surface. The patella being held below by the powerful ligamentum

patellæ rests on the apex of its posterior vertical ridge, which thus becomes the point upon which is developed the greatest energy of the two opposing forces; that of the contractile power of the quadriceps extensor on the one side and the weight of the body on the other. Mechanically it may be stated thus:

The body A. is in the position of a lever of the first order; the muscular force exerted in the direction indicated by the arrow E. being considered as the power, the weight of the body transmitted through the bone B. as the fulcrum, and the resistance to rupture of the band D. as the load or weight. The strength of the lever not being sufficient to resist the strain, the former gives way. So transverse patellar fracture results.

The fibrous and aponeurotic structures lying in front of the patella are more elastic than the bone. When the bone snaps and retracts, the fibrous and aponeurotic tissues over it still holding, bridge the interspace between the fragments. So that they are neither ruptured at the same moment nor at the same level as the bone. If the contraction continues, the aponeurotic and fibrous tissues become overstretched and lose their resilience. When the force is sufficiently great, this bridge gives way, becomes torn into longitudinal strips, and these inelastic shreds rupturing at variable distances are forced into the hiatus between the fractured bone. The majority of these shreds remain attached to the upper patellar fragment, and their extremities would lie loosely over the fractured surfaces if it were not for the fact that, at the moment the transverse fracture ensues, the upper fragment, owing to the manner of insertion of the quadriceps extensor tendon, becomes tilted, so as to present the plane of its fractured surface anteriorly; and as it is drawn upwards, those shreds of præpatellar tissue are pressed firmly over its fractured edge by the flexing of the joint, and the action of the atmospheric pressure forcing the soft tissues inwards to fill up the hiatus. Those shreds thus become fixed to the osseous spiculæ, all of them adhering mechanically in intimate contact with the bone. It thus happens that the serrations on the edge of the broken surface of the upper fragment act like so many pins to which the apon-

eurotic structures become attached and often transfixed. Nor is it only the aponeurotic tissues which are thus driven in between the fragments, but the floor of the patellar bursa is generally ruptured, and portions of it either hang like curtains over the fractured extremities or are firmly fixed to them, being superimposed on the aponeurotic tissue. The tissues which intervene between the fragments and the particular form and arrangement which they assume relatively to the bone, vary according to the case. With those structures intervening between the fragments, osseous union is impossible and even fibrous union will be modified relatively to their extent and arrangement.

Transverse Patellar Fracture without Rupture of the Præpatellar Structures. Occasionally transverse fractures of the patella occur without rupture of the ligamentous and fibrous tissues in front. A young medical man engaged in a football match, while struggling for the ball, was thrown along with several others. He experienced a sharp pain at the knee, but with the exception of aggravating this pain he could walk without much difficulty, though occasionally there was a feeling of crepitation. On examining the patella, he found that there was no hiatus though osseous crepitation was easily detected on lateral movement, the aponeurotic tissues remaining intact. This fact was verified by several surgeons who examined it. The knee-joint was kept stiff, a bandage being applied over the patella. This arrangement was retained for three weeks, the doctor meanwhile walking about. Firm osseous union took place. Some years later the young surgeon showed his limb to the writer who found only a transverse ridge on the patella to mark the seat of the former fracture. The movements of the limb were perfect, and he still engaged in athletic pursuits including football. In this instance the fragments had no intervening tissue between them, and they had the additional advantage of being retained in position by the aponeurotic tissues binding them together, hence the firm osseous union.

It is highly probable that those specimens which are occasionally seen of osseous union after transverse fractures of the

patella have been obtained from patellæ which were fractured without accompanying rupture of the præ-patellar ligamentous structures. It is also stated that fractures of the patella resulting from direct violence are much more likely to result in osseous union. This may arise from the fact that there is here no intervening soft tissue.

In the cases of transverse fracture of the patella that have come under the writer's care, the præ-patellar structures have been found intervening between the fragments and attached to them in the manner described. In order that the reader may form an independent opinion, the appearances found upon examining these cases are here presented.

As the first two cases have already been published in the *Lancet* for November 17, 1883, they are given here only in abstract.

CASE I. *Simple Transverse Fracture of the Patella, Operated on Twenty-four Hours after the Injury.* J. H., æt. 24 years, received a series of injuries in April, 1882, one among them being a transverse fracture of the patella, the lower fragment having a portion of its outer margin broken longitudinally.

An incision in line with the length of the limb was made over the joint, fully exposing the fractured patella. In the extended position of the limb, the upper fragment lay within one inch of the lower, and could be brought close to the latter with slight effort; even placing the hand on the quadriceps extensor and pressing lightly downwards as would be done by a bandage applied externally was sufficient for the purpose. A small quantity of blood clot was in the patellar bursa, the floor of which had given way and lay partly over the surface of the upper fragment and partly over the lower. When the fractured pieces were brought into proximity, the loose floor of the bursa intervened. On elevating the floor of the bursa, which was but slightly attached to the fractured surfaces, it was seen that the aponeurosis from the front of the patella lay over the fractured surface of the proximal fragment to which it was firmly attached, several of the osseous spiculæ having penetrated it. It seemed tightly stretched over the anterior margin, while its distal extremity was ragged and fringed. The lower fragment was not quite so much covered by the aponeurotic structures except laterally, where the ruptured fibrous expansions from the sides of the patella bulged towards the centre of the joint, so as to overlap the

lateral extremities. The structures found intervening between the fragments, therefore, were first the floor of the bursa patellæ; second the præ-patellar aponeurosis, and third the fibrous expansions attached to either side of the patella.

CASE II. *Simple Transverse Fracture of Patella Exposed Twelve Hours after Injury.* R. A., æt. 40 years, had sustained a transverse patellar fracture while endeavouring to prevent himself from falling. A longitudinal incision exposed the parts. The bursal floor was ruptured, the bursa patellæ was partly distended with blood, but the ruptured margins of the floor, owing to the blood behind, bulged forwards away from the fragments. The præ-patellar aponeurotic structures lay in a single piece over the fractured surface of the proximal fragment, the outer two-thirds of which were completely covered, while the inner third had its posterior margin free. This piece was firmly attached to the irregularities of the fractured bone, and had to be scraped up with a periosteal elevator before it was detached. The lower fragment was left exposed, there being no præ-patellar structures covering its fractured surface. It had, like the former case, been divided longitudinally towards its outer third. There was a small quantity of blood clot in the joint. After these structures were elevated, the two fragments lay within half an inch of each other, when the limb was straight, and they could easily be placed in intimate contact. In this case then the præ-patellar aponeurotic structures lay over the proximal fragment to which they were firmly attached, otherwise no other structures intervened.

CASE III. *Simple Transverse Patellar Fracture—Exposed 36 Hours After the Accident.* M. P., æt. 30, was admitted into Ward 29 on May 14, 1885, suffering from a transverse fracture of the patella sustained by muscular effort, while attempting to prevent himself from falling. When he came under observation, 36 hours after the accident, there was not much swelling about the joint. The fragments were completely separated, and lay, when the leg was extended, about half an inch apart. When the fragments were approximated, which could easily be done, and an attempt was made to elicit friction, it resulted in imparting to the fingers a distinct soft sensation, there being no crepitation, even on trying to rub the posterior edge of the fractured surfaces together. Thirty-six hours after the accident, a longitudinal incision was made over the centre of the patella, exposing the fragments. There was only a small quantity of blood clot within the knee-joint, which when removed, revealed the fact that both proximal and distal fragments had their fractured surfaces covered over their whole extent from before backwards with soft tissues. Portions

of the floor of the bursa, which had been ruptured transversely, lay semi-detached between the fragments. Both the upper and lower fragments had their fractured surfaces covered with the aponeurotic tissues, and also with the shreds of the bursal floor, so that there was no part of their fractured surface bare. The soft structures were found to be firmly caught on the projecting bony prominences. Those structures were elevated and the bone was drilled and brought together with silver wire in the ordinary way.

Five weeks afterwards the wound was looked at for the first time and found healed. The silver wire was likewise withdrawn by being wound over dressing forceps. Seven weeks after he was allowed to rise and go about. The movements of the knee were very free at the end of the eighth week.

CASE IV. *Simple Transverse Fracture of Patella—Exposed 14 Hours After the Injury.* W. M., æt. 29, was admitted into Ward 29 in December, 1885, suffering from a transverse fracture of the right patella, which he had received while trying to prevent himself from falling, after slipping on the street. There was very little swelling about the joint. When the limb was extended, the upper portion of the patella lay about two inches apart from the lower, but it could be approximated with ease. A little crepitation was detected, when the posterior edges were rubbed together, though none could be elicited when the patellar surfaces were placed flat against one another. On making a longitudinal incision over the patellar fragments, there was only a very small amount of blood clot seen between the fractured surfaces. After clearing it away, the following condition of the parts was exposed. On the fractured surface of the upper fragment, there was a dense layer of fibrous and aponeurotic tissue, which covered its whole upper aspect, while its inner two-thirds were covered by the same material for about half their diameter. The only portion of the lower fragment which was at first visible was its posterior border, the anterior two-thirds being completely clothed by the fibrous and aponeurotic structures, which hung over the top and covered the sides. When the patellar fragments were brought together and rubbed, these portions of tissue imparted a soft feeling, so much so, that they might be mistaken for blood clot intervening between the fragments. Two long portions of aponeurotic tissue still connected the upper with the lower fragment. These lay doubled in and folded between the fragments. When extended, they measured three and three-quarter inches in length, and were about one-sixteenth of an inch in breadth. They formed part of the aponeurotic bridge, greatly overstretched, but

which had not given away. When the lower borders of the patella were brought together and alone apposed, osseous crepitation could be developed. When the limb was fully extended, the patellar surfaces lay about a couple of inches apart, and could be brought together with very slight traction on the upper fragment. An aperture was formed on both sides of the joint for drainage, and the patellar fragments were united with stout wire, the external portion of the wound being sutured with gut.

It may be noted that the patient was able at the end of the sixth week, when the wires were removed, to bend his knee slightly; and at the end of the eighth week, he walked very well; complete flexion being ultimately restored. The wound had only been dressed once, just after the completion of the operation.

CASE V. *Simple Transverse Fracture of Patella—Exposed 24 Hours After.* J. H., æt. 40, was admitted into Ward 29, April, 1885, suffering from a transverse fracture of the patella, which he had received about 24 hours previously while attempting to prevent himself falling. When the limb was in the extended position, a gap of about two and a half inches existed between the fragments, but these were easily brought close together by digital pressure. On attempting to elicit crepitation, by rubbing the two fractured surfaces, it was found that this was impossible, as soft tissues existed between them, except at their posterior aspect, where on tilting the fragments, so as to bring their posterior edges together, osseous crepitation could be detected. After exposing the patella by a longitudinal incision in the middle line, and after clearing away the blood clot, it was found that a mass of tissue existed between the broken bones. At some points this was fixed to the proximal surface of the fracture by osseous irregularities, which had transfixed the soft parts in such a manner as to hold the soft parts firmly in their abnormal position, almost as if they had been tacked to the bone. The soft tissues which intervened between the fragments consisted of the lacerated floor of the bursa, the folds of which dipped down loosely between the fragments, and when the broken surfaces were approximated, they intervened between them. Then the aponeurosis and periosteal covering were firmly stretched over the proximal fragment and fixed to the osseous projections just mentioned. This portion moved up and down along with the movements of the patella, and it covered the whole diameter of the proximal fractured surface with the exception of the posterior margin. The distal extremity of the patella was broken into three parts. The transverse fractured extremities were likewise covered with portions of the

aponeurosis and periosteum, so as to make it impossible for union to take place. on account of the intervening tissue.

All these structures were elevated, sutures were introduced uniting the fragments, and the wound was dressed. Six weeks subsequently the wires were withdrawn, and eight weeks after the limb was still stiff. At the end of the third month this stiffness was still present to some extent; he could not bend his knee further than a right angle.

CASE VI. *Simple Transverse Fracture of the Patella—Exposed 48 Hours After the Accident.* R. S., æt. 41, came under observation in May, 1885, suffering from a transverse fracture of the patella, received while stepping out of a vehicle in motion. The fragments were about an inch apart, as the limb lay extended There was no crepitation detected on rubbing their surfaces together. Forty-eight hours after the accident, an excision, which exposed the parts, showed a small quantity of blood clot in the bursa, which also dipped down between the fragments. The bursal floor was ruptured, transverse portions of it hung over the fragments and intervened between them when they were approximated. The aponeurotic tissue was tightly stretched over the proximal portion of the patella, and was firmly attached to its fractured surface by the osseous irregularities of the latter. The greater part of the proximal patellar surface was covered, only a slight margin of the articular cartilage being exposed. The distal fragment was alone covered by bursa.

The bone was wired. Three weeks after the wound was examined for the first time, and was found healed. At the end of six weeks the wire was withdrawn. Eight weeks after the patient walked freely about, and could flex his knee to a right angle.

CASE VII. *Simple Transverse Fracture of the Patella—Exposed 24 Hours after the Injury.* A. McD., æt. 53, was admitted into Ward 22 February, 1886, with a transverse fracture of the patella, sustained while he attempted to get off a car in motion. On examining the patient, there was found to be a transverse fracture of the patella with complete separation of the fragments, the distance between them being two inches when the limb was extended. On exposing the fragments by a longitudinal incision over the centre of the knee joint, a mass of blood clot was seen to fill the patellar bursa and to dip down between the fragments into the joint, through the ruptured floor of the bursa. When the blood clot was cleared away the fractured surface of the upper fragment for about one-half of its antero-posterior diameter was found to be covered by aponeurotic structures and commingling with them were shreds of the floor of the ruptured bursa.

These portions of tissue were disposed in a series of folds and were not so closely attached to the fractured surfaces as usual, as with the exception of one or two portions, they could be lifted without the application of the elevator. When these portions of tissue were raised and extended, they measured from half an inch to an inch and one-eighth in length. The two posterior thirds of the lower fragment were covered by a band of aponeurotic tissue, measuring a quarter of an inch in breadth and running transversely across the joint, from the inner to the outer side. This band was somewhat broken up into transverse strips, which were firmly fixed to the osseous spiculæ on the fractured surface. When this band was relieved from the osseous spiculæ which transfixed it, it slid into the knee joint under the lower fragment. The posterior edge of this fragment then became tilted anteriorly, so that while it was easy to approximate the posterior edges of the fractured surfaces, it was very difficult to bring the anterior ones together, owing to the resilient resistance which this band offered. After removal of this band the fractured surfaces were easily placed in apposition.

The usual treatment was adopted.

This patient never had a bad symptom: the wound healed by first intention. The wire was withdrawn at the end of the sixth week. At the end of three month the movements were quite restored, firm osseous union having been obtained.

CASE VIII. *Simple Transverse Fracture of Patella—Exposed* 14 *Days After the Accident.*

S. Q., æt. 35, was admitted into Ward 22, in April 1886, suffering from a transverse fracture of the patella, which she received 14 days previously, by muscular violence, while attempting to prevent herself from falling down stairs. When the limb was extended, the upper part of the patella was about one inch apart from the lower. When the knee-joint was opened, the patella was found to have been fractured at the junction of its middle with its lower third. The interval between the fragments was filled with blood clot, and so also was the bursa patellæ, the anterior wall of which was intact and thickened with effusion, while the posterior wall was ruptured and formed the anterior layer of a flap of tissue which lay over and covered in completely the proximal patellar fragment, no part of its osseous wall being exposed. This flap of soft tissue effectually prevented crepitation, even when the posterior parts as thus exposed were approximated. On carefully separating the bursal floor from the underlying flap of soft tissues, it was seen that the next layer consisted of long shreds of ligamentous structures, which were firmly adherent to the spiculæ of the cancellated

tissue of the upper fragment. The majority of these shreds were quite as long as the breadth of the fractured surface, some ending at the posterior cartilage, others forming a slight fringe which projected into the joint. One shred, which measured from the anterior margin of the fracture was fully two inches in length, had its upper part fixed to the bone while its lower lay loosely in the joint. Several of these ligamentous shreds were curled up at their extremities and lay in the interstices of the bone. These had to be removed by means of the periosteal elevator, many of them having to be scraped out. After doing so, there was found to be a portion of osseous tissue adhering to the ligamentous structures and lying anteriorly and a little over the fractured surface of the upper fragment. This osseous tissue had been removed, along with the fibrous and ligamentous bands to which it still adhered, from the anterior aspect of the distal fragment; so that here the flaps over the front of the upper fragment, consisted of: First, the floor of the bursa patellæ; second, the fibrous and ligamentous structures covering the patella; third, a small portion of the osseous substance from the anterior surface of the lower fragment. The fractured surface of the lower fragment was comparatively free, except for bands of well formed fibrin. The synovial membrane of the joint was swollen and highly injected and projected slightly between the lower borders of the fragments.

The usual treatment of elevation of the interposed tissues and suturing was adopted. The wire was withdrawn six weeks after, when the dressings were removed for the first time. The patient walks freely about without any stiffness.

Since publishing the first paper on this subject there have been a number of cases published of tranverse fractures of the patella, in which the aponeurotic tissue has been detected between the fragments in the manner described. Among these was one described by Dr. Fowler, of New York, in which he found the aponeurotic tissue dipping down between the fragments of a transverse fracture of the patella, in such a way as to prevent the possibility of union by bone. Dr. Hardy, of Manchester, has kindly informed me that he has found the aponeurotic tissue intervening between the fragments in three instances. "In one, a piece as thick as a penholder and two and a half inches long was turned over the upper fragment and lay in the joint. In another, a considerable quantity of fibrous

tissue was intimately adherent to the whole width of the broken surface and required to be carefully picked off. In a third, the upper fragment had, as it appeared, forced itself through a transverse cut, so that a string-like piece of fibrous tissue, connected at its two ends, lay underneath the patella in contact with its articular surface. Some small shreds were also closely applied to the broken surface. A specimen somewhat resembling the condition described as existing in Mr. Hardy's last case was presented by Mr. Maylard to the Pathological Society. It was taken from the subject. The patient was one of Dr. Cameron's who had not been operated on for transverse patellar fracture, but who had died from heart disease. There was a quantity of aponeurotic tissue intervening,

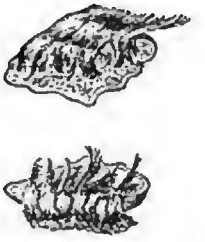

FIG. 3. TRANSVERSE FRACTURE OF PATELLA. (Diagrammatic) presentation. Patellar fractured surfaces seen from before with shreds of ruptured aponeurotic tissues overhanging them.

and one portion of it lay transversely stretching across the fractured surface. Besides the published cases spoken of the writer has been assured by several surgeons that they have met with similar arrangements of the præ-patellar tissues in transverse fractures of the patella.

Here are thirteen cases of transverse fractures of the patella, in which portions of soft tissue intervened between the fragments in such a manner as to render osseous union an impossibility. When it is remembered that eight of these cases which fell under personal observation, were consecutive, the probability is that in the majority of transverse patellar fract-

ures, the same causes are at work in preventing osseous union. It may also be gathered from a survey of these cases, that too much stress has hitherto been placed on the contractions of the quadriceps muscle, as well as on the presence of blood clot in the joint, as causes of non-osseous union. They exist as factors which require consideration, but they are of minor importance. The true cause of non-osseous union in transverse fractures of the patella lies in the fact of the interposition of the aponeurotic and bursal structures between the fragments. Transverse patellar fractures occasioned by muscular violence are especially prone to have these structures intervening. Patellar fractures occasioned by direct violence, which are often more or less stellar, seldom have complete rupture of the aponeurotic structures accompanying them, and consequently have better opportunities of becoming closely

FIG. 4. TRANSVERSE FRACTURE OF PATELLA; LONGITUDINAL SECTION (representing ruptured aponeurotic tissue, arranged as in No. 3, but the extremity of the tissue has been elevated from the bone).

united by fibrous union, or even by osseous union, without operative intervention. Fractures in which the lower fragment only is multiple from having been divided by contact with some external body met with in the fall subsequent to the occurrence of the transverse fracture from direct violence, ought not to be included under this group.

The following may be taken as a summary of the pathological conditions met with in transverse fracture of the patella.

The præ-patellar tissues, found to intervene between the fragments, consist of the floor of the patellar bursa and the aponeurotic and fibrous tissues.

The floor of the patellar bursa intervenes in a variety of ways, occasionally it represents transverse bands and flaps, at others, a series of shreds, all of these hanging between the fragments of bone or folded more or less loosely over them.

Often the bursal floor is much congested and thickened from irritation and possibly also by imbibition.

The aponeurotic tissues are those which are most intimately connected with the fractured surfaces and especially to that of the proximal fragment.

They assume various forms:

1. That of a flap, tightly stretched over the anterior portion of the fractured surface of the proximal fragment and fixed firmly to its osseous irregularities, ending in a fimbriated extremity, some of the shreds of which dip into the joint, while others are broken off near the posterior border of the articular patellar cartilage. (Figs. 3 and 4).

2. Shreds of greatly overstretched ligamentous structures lying in and fixed to the osseous irregularities of the fractured

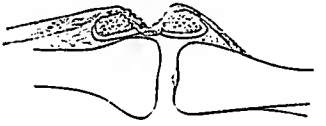

FIG. 5. TRANSVERSE FRACTURE OF PATELLA (longitudinal section with shreds of overstretched aponeurotic tissue extending in continuity from proximal to distal fragments and dipping down between them).

surface. These are more or less continuous transversely along the anterior border of the patella, but are scattered over the fractured surface as they approach the posterior edge. The lengths of these shreds are very varied, some not covering the whole fractured surface, while others not only do so but lie in the joint beyond.

3. Occasionally there are shreds of overstretched aponeurotic tissues adhering by their extremities to both proximal and distal fragments, while in the centre they fall into the joint in the form of long loops. (Fig. 5.)

4. In three instances bands of tissue existed which extended from the inner to the outer side of the joint running transversely. In the instance of this kind, which fell under personal observation, the band which was stretched across the

lower fragment slipped while an attempt was being made to place it front of the patella, it then lay between the joint and and the bone. The lower fragment then became tilted in such a mannner as to make it impossible to bring the fragments into close contact while this band existed in that position. In Mr. Hardy's case, a similar band actually lay under the lower fragment when he opened the joint. In such cases it is difficult to see how coaptation could be secured without removal of the band. The existence of bands of this kind lying under the patella, but which have not been suspected,

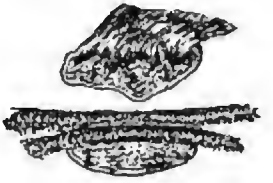

FIG. 6. TRANSVERSE FRACTURE OF THE PATELLA (fractured surfaces seen from before. Transverse band of aponeurotic tissue extending across the joint from inner to outer side, covering the posterior aspect of lower fragment).

may account for the exceptional difficulty, which has sometimes been met with, in approximating the fragments. Opening the joint; dividing the band, removing it, or replacing it in front of the patella, and securing it there, at once removes the difficulty.

5. The fractured surface of the distal fragment is generally much freer from aponeurotic tissue than the proximal one; but it also has its share. When the proximal one has a very large flap to cover it, the distal one is correspondingly free; though occasionally, when free from aponeurotic tissue, it is covered by the ruptured bursal floor.

6. The part of the fractured surfaces which is most free from these intervening structures is the posterior edge; hence, though it be impossible to elicit crepitation while rubbing the two fractured surfaces fairly against one another, it is often easy to do so, if the patella be tilted so as to bring the posterior edges together.

Having established this point in the pathology of transverse fractures of the patella, surgeons will be able to choose their own treatment and to measure beforehand what they are likely to expect from it. From these observations one must conclude that if osseous union be desired, the soft tissues ought to be removed from between the fractured surfaces. If this be not done, fibrous union will ensue, except in a few of those cases which have resulted from direct external violence. Regarding fibrous union of a fractured patella, some believe it to be satisfactory. The instances which have come under personal observation have been far from being so when traced during the first few years subsequent to the fracture. They look well in hospital, but several of them, after being treated for three or four months, have within various short periods of their dismissal, had the fibrous union so much elongated, or ruptured, that the leg was rendered again useless, except when supported by a back splint, or other mechanism. Occasionally, firmer union does occur, and the patient goes about with a useful limb; but no one at the outset of the treatment can presage the result of the fibrous union. The result is uncertain, and must be so, as long as there is this variety of disposition of intervening soft structures. It frequently happens that this fibrous union has formed not between bone and bone, but between the layers of intervening aponeurotic tissue; and when strain has been put on it, the attachments of the latter to the bone give way, thus leaving a band elongated by the length of the intervening substance. This is the explanation of the sudden lengthening of the connecting band which so often ensues. Osseous union is therefore desirable, and that method of treatment which can secure this end with a regularity which can be depended upon, is what ought to be aimed at. Mr. Millar, of Edinburgh, has recently tried to secure this by means of rubbing the fractured edges together without opening the joint, and says that he has had some good results. Under certain circumstances this might be sufficient. If, for instance, the fractured surface formed a transverse line evenly exposed, or exposed over the greater part of its extent, to the friction, and especially if the amount of aponeurotic tissue in-

tervening were not great, the result might be satisfactory. It is, however, comparatively seldom that such conditions exist, and as there may be difficulty in ascertaining from external manipulation, the precise form of the fracture, it is more certain and safer to expose the parts by incision. There may, however, be circumstances which may preclude opening of the joint. The patient's general health may be in such a state as to render any cutting operation hazardous; therefore, it is well to consider how best to carry out the attempt of removing the intervening præ-patellar tissues. With this view a few suggestions may be made. First, it ought to be borne in mind that osseous crepitation can be elicited by rubbing the posterior edges of the fractured surfaces together, but one must not therefore conclude that the whole width of the fractured surfaces are free, as it is frequently the case, that the posterior edges are exposed, when the whole of the remainder is covered with aponeurotic tissue. Second, osseous crepitation may be elicited from the bony projections penetrating the aponeurotic tissue which lies close to the fracture. Therefore, though osseous crepitation may be produced, one must not believe that the principal part of the aponeurotic tissues have been removed. Thirdly, the proximal fragment is the one which is principally covered by aponeurotic tissues and therefore it should receive most attention. Fourthly, as the intervening soft parts fall over the edges of the fractures from before backwards, one should endeavor to get rid of these structures, by scraping the one fragment against the other from behind forwards, so as to dislodge these tissues. This plan could not dislodge the transverse bands existing underneath the torn fragment.

Exposure of the fracture by a longitudinal incision is the surest way of effecting this purpose.

The treatment of fracture of the patella by opening the knee joint was introduced by Professor Cooper, of San Francisco, in 1861, and subsequently reintroduced by Professor Lister. The opening of the joint was resorted to, not for the purpose of removing the intervening soft tissues, as this had not been recognized as a cause of non-osseous union; but with the view of

wiring the fracture. By opening the knee-joint, the whole state of the parts lie at once revealed. All intervening structures ought then to be removed and accurate apposition of the fragments effected. With this view, other things being equal, the earlier the fracture is treated the better. A longitudinal incision, several inches in length, is made over the patella, the parts are carefully examined, the intervening aponeurotic and bursal structures are removed, the joint washed out, and the fractured surfaces brought into apposition by wire. The ends of the wire are left projecting from the wound, but turned down flat upon the skin; and at the expiry of six weeks are removed by untwisting the wire, cutting off one end and winding the remainder round dressing forceps.

Van der Meulen, of Utrecht, in wiring bones gives the wire a single twist, cuts off the redundancy, and hammers the extremities flat into the bone; and that practice has been generally adopted in wiring the patella. In bones such as the shaft of the femur, lying at a considerable depth from the surface, the practice is one which has advantages; but in bones so superficial as the patella, these are not apparent. After the union of the bone the wire remains as a useless foreign body, in many, probably in the majority, not doing harm; but in a few mechanically exciting irritation, leading occasionally to serious results. If union does not take place the wire will "eat its way out," by producing absorption or ulceration of the bone. In one such case, which came under observation three months after the patella had been sutured, the knee-joint was in a state of acute suppurative arthritis, with ulceration of cartilage. The fractured surfaces were still movable one upon the other, on firm lateral movement, they having only become united by soft fibrous union. A sinus existed over the patella, and on passing a probe, it came in contact with the wire which was surrounded by a carious condition of the bone. The twist in the wire was still intact, but the loop itself was loose; the osseous tissue having become inflamed, softened and ulcerated in front of it. Excision of the joint was demanded to relieve his sufferings. When the joint was opened, the wire was found to have eroded its way almost entirely through the proxima

fragment, leaving the osseous tissue in its wake inflamed and softened. From the history of the case and the examination of the joint, it appeared that the inflammatory condition had originated in the immediate neighborhood of the patella. The patient was a strong healthy man, and one who was unlikely to be the subject of joint disease arising from other than local irritation. So, looking on the possibility of irritation arising from the wire being left *in situ*, it seems better to remove it after it has served its purpose. At the expiry of six weeks the wire ought to be removed. This may be best done by first straightening the wire, cutting off the one end close to the wound and then grasping the other end in a pair of forceps (ordinary dressing) and winding the wire over it. In this way all jerking is removed and the wire is extracted evenly and steadily. (See Fig. 7).

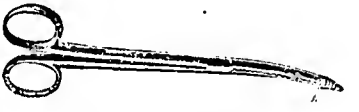

FIG. 7. DRESSING FORCEPS; winding wire round them in process of removing it from the patella.

Regarding the re-establishment of movement in the joint all violence ought to be avoided, and passive movement ought to be undertaken with discrimination, or rupture of the fresh osseous union before it has been completely consolidated might ensue. The patient might, however, exercise the limb freely at the expiry of eight weeks. Massage greatly facilitates the freedom of the joint.

TRANSVERSE FRACTURES OF THE OLECRANON.—In transverse fractures of the olecranon a somewhat similar disposition of the aponeurotic tissue relatively to the fractured extremities obtains and in some cases is sufficient to prevent osseous union. Three instances of this kind have come under notice requiring operation, and in each the aponeurotic tissues were found intervening between the fragments.

CASE I. *Transverse Fracture of the Olecranon, Operated on Twelve Hours after the Accident.*

J. L., æt. 24, was admitted March 27th, 1883, suffering from a simple multiple fracture of the olecranon which he received by accident, though the precise mechanism of the injury could not be ascertained. There was a considerable gap between the fragments. An incision was made over the olecranon exposing the fracture. A dense layer of aponeurotic tissue lay over the fractured surface of the exposed fragment completely covering it. This tissue had been torn from the posterior surface of the distal part or shaft of the ulna. There was also a quantity of blood lying in the interval between the fractured surfaces.

These soft parts were elevated, and the bone was united by means of silver wire. There was no pus formation, and he ultimately had a strong, useful and freely movable arm. There was firm and apparent osseous union obtained.

CASE II. *Transverse Fracture of the Olecranon Exposed Three Hours after the Injury.* L. L., æt. 30, was admitted under observation in November, 1884, suffering from a fracture of the olecranon which he had received three hours previously while engaged in lifting a heavy weight on to a cart. The upper fragment was fully an inch from the lower one. On bringing the fragments into close contact no crepitation was detected, but a sensation was imparted as if blood clot had intervened. An incision was made over the fragments, and when exposed and the intervening blood removed, there was seen to be a flap of aponeurotic tissue lying over and completely concealing the proximal fragment, while on the ulnar border of the fractured surface, there were a few shreds of the same tissue. The flap of aponeurotic tissue lying over the upper fragment moved with it, and was slightly attached to it by means of its osseous irregularities, but it was not held together in the same firm way as the soft tissues in front of the patella are in transverse fractures of that bone. As long as this flap of tissue existed between the fragments it was quite impossible to obtain osseous union.

These tissues were elevated, and the fragments were brought together with wire. Firm osseous union was obtained along with free movement. There had been no increase of temperature and no second dressing was required.

CASE III. *Transverse Fracture of Olecranon—Exposed Twelve Hours after Accident.* S. P., æt. 34, came under observation in February, 1885. Had been engaged in a struggle with a comrade when he felt a something giving way in his right arm. This occurred about twelve hours before he entered hospital. On examination, the olecranon was found to be separated from the shaft, and on attempting

to elicit crepitation, none was detected, the effort imparting a soft sensation to the fingers. An incision exposed the fragments. There was little blood clot in the gap between the bones. The proximal fragment was partially concealed by shreds of aponeurotic tissue, which covered the greater part of its fractured surface. The part attached to the shaft of the ulna was likewise covered by shreds of tissue from the ligamentous structures behind. Some of these shreds were firmly fixed to the bone, but there were others which lay loosely between the fragments, being attached only to one of them.

These soft tissues were elevated, and after the bone was sutured they were brought together over the dorsal aspect of the fragments. The wound healed by first intention. Movements were commenced a few days after the wiring. The wire was withdrawn a month subsequently. The movements were free six weeks after the operation.

To these three cases may be added a fourth, which illustrates the manner in which fractures from direct violence are more likely to become united by osseous union than those which are the result of muscular effort.

CASE IV. *Compound Comminuted Fracture of the Olecranon.* In March, 1885, L. S., æt. 29, came under observation four hours after he had sustained a compound comminuted fracture of the olecranon by falling from a height on his elbow. The wound exposed the olecranon, broken into four fragments, which lay slightly separated from one another. There were very few of the fibres of the aponeurosis completely ruptured, though they were evidently considerably stretched, and a few were divided but lay on the surface of the fragments. Osseous crepitation was easily elicited on movements of the fragments in any direction. There was here no reason why osseous union should not take place, as there was nothing to prevent it. It presented quite a contrast in this respect to the others cases mentioned above.

The wound was treated in the usual way, there was no suppuration and only one dressing was required. Firm osseous union resulted, but there was considerable stiffness, especially at first. Ultimately, he was able to flex the arm sufficiently to touch his mouth and to extend it almost completely.